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Original Article

Road Damage Analysis Using the Analytical Hierarchy Process Method Based on Provincial/District Road Management System as the Basis for Road Handling Program

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Abstract

This study aims to determine the priority order of road handling in Pacitan Regency using the Analytical Hierarchy Process (AHP) method in combination with the Provincial/District Road Management System (PRMS) application. This research involved provincial roads in Pacitan District, with primary data collection through field surveys and AHP questionnaires distributed to experts. The results of the analysis show that combining the PRMS and AHP methods provides a more accurate and objective prioritization order, with the final result identifying the road sections that need the most urgent handling. prioritization of road handling based on AHP and PRMS methods. Based on the criteria weighting results, the Wareng - Mukus section has the highest priority with a weight of 0.24, followed by the Arjosari - Purwantoro section with a weight of 0.23, and the Bts. Ponorogo Regency - Bts. Pacitan City with a weight of 0.21. In the PRMS analysis, road handling priorities based on TPI (Infrastructure Priority Level) also show similar results, with the Wareng - Mukus section as the highest priority (TPI 33.1), followed by the Bts. Ponorogo Regency - Bts. Pacitan City (TPI 12.2), and the Arjosari - Purwantoro section (TPI 11.2). This research is expected to provide useful recommendations for road management and planning in Pacitan District.

Keywords: Road Handling Prioritization, AHP, PRMS.

1. Introduction

Roads as part of land transportation facilities and infrastructure have a dominant role compared to other modes of transportation (Dwiyahreni et al., 2021; Okate & Kakade, 2019)v. Data shows that land transportation is still the backbone of human and goods movement in Indonesia, including in Pacitan District. The district has a challenging topography, which makes land transportation the only main alternative to support the economic and social activities of the local community. The roads in Pacitan District managed by the East Java Provincial Government have a total length of 102.73 kilometers (East Java Governor Decree, 2023), which are divided into five main roads. These roads are vital routes that connect various areas in Pacitan with the rest of East Java.

However, the limited budget availability each year has forced the East Java Provincial Government, particularly the Bina Marga Public Works Office, to prioritize road maintenance (Astasari et al., 2024). This prioritisation aims to ensure that road sections in the greatest need of repair or maintenance receive the most attention. In this context, road prioritization

analysis becomes very important to support effective and efficient data-based decision making.

There are several scientific methods that can be used in road management priority analysis, including the Analytical Hierarchy Process (AHP) and the Provincial/District Road Management System (PRMS). AHP is a method that is often used to determine priorities through a systematic decision-making approach, based on pairwise comparisons between various criteria (Saaty, 1980). On the other hand, PRMS is a specialized program designed to assist local governments in managing road networks in an integrated manner. By utilizing technical data such as road condition, traffic volume, and inter-regional connectivity, PRMS provides recommendations based on in-depth analysis. The combination of AHP and PRMS is expected to result in more accurate and well-implemented road management prioritization decisions (Prijambodo & Baihaqi, 2020).

In Pacitan District, the application of a combination of AHP and PRMS methods has high relevance (Kusnadi & Warnars, 2021). This combination allows decision-making that is not only based on technical data, but also considers non-technical factors, such as surveys of the community as road users. Thus, the process can lead to more comprehensive decisions that reflect the needs and aspirations of the community. One of the advantages of this approach is the ability to balance technical requirements with input from road users, which in turn improves the effectiveness of budget allocation and implementation of road improvement programmes (Boamah, 2010).

This research aims to analyse road damage using the PRMS-based AHP method as a basis for road handling programs on provincial roads in Pacitan Regency. The main focus of this research is to identify road improvement priorities based on a combination of technical and nontechnical data, so as to support better and more targeted planning. In this context, technical data includes road condition, connectivity, traffic volume, and the function of the road as a link for public services. Meanwhile, nontechnical data was obtained through a survey to the community to understand their perceptions and needs related to road conditions.

The application of the PRMS-based AHP method is expected to provide significant benefits in managing the road network in Pacitan District. With the combination of technical and nontechnical data, road management priority decisions are not only based on physical conditions, but also on social and economic aspects. For example, road sections that function as the main link between regions or that have a high level of economic activity can be prioritised even though their physical condition is not yet in the category of severe damage. This is in line with the concept of sustainable development, which emphasises the importance of balancing economic, social and environmental needs (Riverson et al., 1991).

In its application, the first step is to collect technical data through the PRMS programme. This data includes road condition, level of damage, traffic volume, and road connectivity function. The data is then processed to determine the level of repair or maintenance needs. Furthermore, non-technical data was collected through a survey to the road user community. This survey aims to obtain information on the level of public satisfaction with road conditions as well as their priorities for road management.

For example, the connectivity criterion may have a higher weighting than the traffic volume criterion, as roads connecting strategic areas tend to have a greater impact on the regional economy. Similarly, criteria connecting public services such as schools, hospitals or markets may be given higher priority due to their crucial role in supporting people's daily activities (Haynes, 1984).

Overall, the combination of the AHP and PRMS methods offers an innovative approach to road management. By combining the advantages of these two methods, namely the ability

of AHP to capture nontechnical aspects and the flexibility of PRMS in analysing technical data, it is expected that road management in Pacitan District can be carried out more effectively and sustainably. This research also demonstrates the importance of data-driven decision-making in public infrastructure management, which in turn will support more inclusive and sustainable development efforts.

From the background explanation above, the purpose of this research is to determine the priority order of road handling in Pacitan District using the AHP method, to determine the results of priority analysis based on qualitative considerations obtained through expert or stakeholder assessments. As well as analysing the priority order of road handling in Pacitan District using a combination of the PRMS application and the AHP method, to test whether the combination of these two methods can provide more optimal results in determining road handling priorities.

2. Methods

This study used research subjects consisting of provincial road sections in Pacitan District. The research location included several provincial road sections in the area, with an estimated implementation time of two weeks. This time includes the observation survey process, field data collection, and data analysis.

The instruments used in this research included various technological devices such as GPS, distance measuring devices, cars, tablets/laptops, and Microsoft Access to access the PRMS application. Data collection was conducted through two types of data, namely primary data and secondary data. Primary data was obtained from a literature study that included administrative data, a list of road sections, and unit prices for road handling. Meanwhile, secondary data was obtained through field surveys that included road inventory, road conditions, and traffic data.

The data analysis technique used is descriptive qualitative analysis, where the data obtained will be analysed and described to find a solution to the research problem formulation. At this stage, the analysis is carried out using two methods, namely PRMS and AHP. The data that has been collected will then be inputted into the PRMS application to carry out the analysis process, which produces information related to road conditions, handling priorities, and estimated costs needed for road handling in the next five years. The analysis steps in the PRMS application include inputting administrative data, road network arrangement, road inventory, road condition, road structure, traffic data, and road handling unit price, followed by an analysis process to determine road handling priorities based on the TPI value.

In addition, this study also analyses the priority of alternative road treatments using the results of the AHP questionnaire. Primary data in the form of AHP questionnaires distributed to expert respondents will be analysed to obtain the order of road handling priorities on the five roads analysed. The results of this analysis are expected to provide an overview of the most urgent road handling priorities to be addressed based on the assessment of expert respondents.

3. Results and Discussion

3.1. PRMS Application Analysis

After the data entry process for the 5 (five) district roads that became the object of research, the analysis was carried out using Multi-Criteria Analysis (MCA) parameters with a weight of 100% on Criterion 1, namely Road Condition and Traffic Volume. This parameter is

used to provide a priority assessment that focuses on these two main aspects. From this analysis process, a report was generated from the PRMS (Provincial/District Road Management System) system that presents a list of road sections based on the Triggered Priority Index (TPI). The results of this report provide an overview of the priority order of road handling based on actual conditions and parameters that have been analysed. The details of the analysis results can be further explained as follows:

Table 1. PRMS Analysis Results

No	Section Name	MW (5 Year) - Total Maintenance Price (Rp Million)	TPI Class	TPI	WorkType
1	Bts. Ponorogo Regency - Bts. Pacitan City	16.777,5	10-AC	10,8	2MW
2	Tentara Pelajar Street	1.681,6	10-AC	14,8	2MW
3	Arjosari - Purwantoro (Bts. Central Java Province)	47.596,9	10-AC	19,4	2MW
4	Basuki Racmad Street	57,6	10-AC	32,8	2MW
5	Wareng - Mukus (Bts. Central Java Province)	3.830,7	10-AC	82,6	2MW

Table 2. Priority Weights Based on PRMS

No	Section Name	TPI	Order of Priority
1	Bts. Ponorogo Regency - Bts. Pacitan City	10,8	5
2	Tentara Pelajar Street	14,8	4
3	Arjosari - Purwantoro (Bts. Central Java Province)	19,4	3
4	Basuki Racmad Street	32,8	2
5	Wareng - Mukus (Bts. Central Java Province)	82,6	1

3.2. Analysis Method of Analytical Hierarchy Process

Based on the analysis of the weights of road section criteria, both from technical data and AHP (Analytic Hierarchy Process) questionnaires, results are obtained that describe the level of importance of each criterion in determining road handling priorities. These results combine objective data and respondents' perceptions, providing a comprehensive basis for formulating handling priorities. Details of the analysis results are as follows:

Table 3. Priority Weights Based on AHP

Section Name	Road Section Data Weight					AHP Questionnaire Weight						Global Priority Weight	Priority
	K1	K2	K3	K4	K5	K6	K1	K2	K3	K4	K5	K6		
Bts. Ponorogo Regency - Bts. Pacitan City	0,20	0,19	0,14	0,33	0,33	0,20	0,14	0,04	0,35	0,12	0,13	0,22	0,21	3

Section Name	Road Section Data Weight					AHP Questionnaire Weight						Global Priority Weight	Priority
	K1	K2	K3	K4	K5	K6	K1	K2	K3	K4	K5	K6		
Tentara Pelajar Street (Pacitan)	0,20	0,25	0,14	0,00	0,17	0,20	0,14	0,04	0,35	0,12	0,13	0,22	0,15	5
Basuki Racmad Street (Pacitan)	0,20	0,19	0,29	0,00	0,00	0,10	0,14	0,04	0,35	0,12	0,13	0,22	0,16	4
Arjosari - Purwantoro (Bts. Central Java Province)	0,20	0,19	0,14	0,33	0,33	0,30	0,14	0,04	0,35	0,12	0,13	0,22	0,23	2
Wareng - Mukus	0,20	0,19	0,29	0,33	0,17	0,20	0,14	0,04	0,35	0,12	0,13	0,22	0,24	1

3.3. Analysis of PRMS Application combined with AHP method

After completing the data input process on five (5) Provincial road sections located in Pacitan District, an in-depth analysis was conducted using the PRMS (Provincial/District Road Management System) system. This analysis involved creating a list of road sections, along with the calculation of the Triggered Priority Index (TPI) for each road section. In the process, Multi-Criteria Analysis (MCA) values were carefully calculated based on data obtained from the Analytic Hierarchy Process (AHP) questionnaire. The AHP questionnaire is used as a tool to objectively evaluate and prioritise by considering various relevant criteria. The results of this analysis provide an overall picture of the condition of the road sections and their prioritisation, which is summarised below:

Table 4. MCA criteria based on AHP

No	MCA criteria in PRMS application	MCA Parameter Value from AHP result
1	Criteria 1 (Road Condition and Traffic Volume)	(14% + 4%) = 18%
2	Criteria 2 (Connectivity)	35%
3	Criteria 3 (Area Development)	12%
4	Criteria 4 (Connecting Economic and Agricultural Areas)	13%
5	Criteria 5 (Connecting Public Service Facilities)	22%

The Multi-Criteria Analysis (MCA) score for each road section processed in the PRMS (Provincial/District Road Management System) application has been determined based on the analysis of road section weights as listed in Table 4. This assessment was conducted using three main categories: low with a score of 1, medium with a score of 2, and high with a score of 3. These categories have been adjusted to the parameters applied in the PRMS application to provide an objective and systematic evaluation of the condition of the road section. The details of these scores are as follows:

Table 5. Criteria Categories Based on AHP

Space	AHP Weight				Category			
	K3	K4	K5	K6	K3	K4	K5	K6
Bts. Ponorogo Regency - Bts. Pacitan City	0,14	0,33	0,33	0,20	2	3	3	3
Tentara Pelajar street (Pacitan)	0,14	0,00	0,17	0,20	2	1	2	3
Basuki Racmad street (Pacitan)	0,29	0,00	0,00	0,10	3	1	1	1
Arjosari - Purwantoro (Bts. Central Java Province)	0,14	0,33	0,33	0,30	2	3	3	3
Wareng - Mukus	0,29	0,33	0,17	0,20	3	3	3	3

Description
Low = 1, weight value of road section < 0.12
Medium = 2, road section weight value 0.12 to 0.16
High = 3, road section weight value > 0.16

Based on the results of previous calculations and analyses, the priority order for each road section has been determined through the combined application of the PRMS (Provincial/District Road Management System) application with the AHP (Analytic Hierarchy Process) method (Saaty, 1980). This process combines the results of the road condition evaluation using the PRMS system and the prioritisation considerations obtained through the assessment of criteria in the AHP method. Thus, the priority order of road sections that need the most attention and urgent treatment can be identified more accurately and objectively. The following is the priority order of road sections based on the results of the analysis:

Table 6. PRMS Analysis Results of AHP Combination

	Section Name	Mw (5 Year) - Total Maintenance Price (Rp Million)	Tpi Class	Tpi	Worktype
1	Wareng - Mukus (Bts. Central Java Province)	5.136,9	10-Ac	33,1	2mw
2	Bts. Ponorogo Regency - Bts. Pacitan City	19.231,0	10-Ac	12,2	2mw
3	Arjosari - Purwantoro (Bts. Central Java Province)	21.731,2	10-Ac	11,2	2mw
4	Basuki Racmad Street	72,0	10-Ac	8,2	2mw
5	Tentara Pelajar Street	1.599,3	10-Ac	7,6	2mw

Table 7. PRMS Priority Weights AHP Combination

No.	Section Name	TPI	Prirority
1	Wareng - Mukus (Bts. Central Java Province)	33,1	1
2	Bts. Ponorogo Regency - Bts. Pacitan City	12,2	2
3	Arjosari - Purwantoro (Bts. Central Java Province)	11,2	3
4	Basuki Racmad Street	8,2	4
5	Tentara Pelajar Street	7,6	5

3.4. Recapitulation of Road Handling Priority Order

Based on the results of the analyses conducted, there are three alternative approaches used to determine the order of priority in road management. The first approach is to use the Analytic Hierarchy Process (AHP) method, which utilises hierarchical analysis to assess various criteria relevant to decision-making (Saaty, 2008). The second approach uses the Provincial/District Road Management System (PRMS), which focuses more on evaluating the physical condition and strategic management aspects of roads. The third approach is a combination of the two previous methods, combining PRMS with AHP to produce a more comprehensive analysis. The results of the three alternative approaches have been analysed in detail, and the results are summarised and presented in the following table. This table aims to provide a clear and structured picture of the prioritisation of road management based on the methods used, so as to support a more effective and accurate decision-making process.

Table 8. Recap of Road Handling Priority Order

No.	Section Name	PRMS Application		AHP Method		PRMS Application Combination AHP Method	
		TPI Value	Priority Order	Global Priority Weight	Priority Order	TPI Value	Priority Order
1	Bts. Ponorogo Regency - Bts. Pacitan City	10,8	5	0,21	3	12,2	2
2	Tentara Pelajar Street (Pacitan)	14,8	4	0,15	5	7,6	5
3	Basuki Racmad Street (Pacitan)	19,4	3	0,16	4	8,2	4
4	Arjosari - Purwantoro (BTS. Central Java Province)	32,8	2	0,23	2	11,2	3
5	Wareng - Mukus	82,6	1	0,24	1	33,1	1

4. Conclusion

Based on the analysis using the AHP method and the weight value of the criteria, the global weight shows the difference in the priority level of road handling. The Wareng - Mukus section has the highest weight of 0.24 and is the first priority, followed by Arjosari - Purwantoro with a weight of 0.23 as the second priority. The Bts. Ponorogo Regency - Bts. Pacitan City is third with a weight of 0.21, while Basuki Racmad street 0.16 and Tentara Pelajar street 0.15 are the fourth and fifth priorities.

Based on the results of PRMS analysis combined with AHP, the priority order of road handling shows that the Wareng - Mukus section (Bts. Central Java Prov.) has the highest priority with a TPI of 33.1. Followed by the section of Bts. Ponorogo Regency - Bts. Pacitan City with a TPI of 12.2, which is the second priority. The Arjosari - Purwantoro section (Bts. Central Java Prov.) is the third priority with a TPI of 11.2, while Basuki Racmad street and Tentara Pelajar street are the fourth and fifth priorities with TPIs of 8.2 and 7.6, respectively.

In this study, the use of PRMS application is only limited to determining the priority order of road sections based on the TPI value. As such, it is recommended that future research

include the utilisation of all features available in the PRMS application. For example, features related to road asset management that can generate medium-term (five-year) projections for road handling programs can be optimised. The utilisation of this feature is expected to provide more significant added value in supporting road management and handling at the district level.

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